Passive Cigarette Smoke, Coal Heating, and Respiratory Symptoms of Nonsmoking Women in China

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In this study we evaluated data from a sample of 973 never-smoking women, ages 20–40, who worked in three similar textile mills in Anhui Province, China. We compared prevalence rates of respiratory symptoms across homes with and without coal heating and homes with different numbers of smokers. Multiple logistic regression models that controlled for age, job title, and mill of employment were also estimated. Respiratory symptoms were associated with combined exposure to passive cigarette smoke and coal heating. Effects of passive cigarette smoke and coal heating on respiratory symptoms appeared to be nearly additive, suggesting a dose–response relationship between respiratory symptoms and home indoor air pollution from these two sources. The prevalence of chest illness, cough, phlegm, and shortness of breath (but not wheeze) was significantly elevated for women living in homes with both smokers and coal heating. *Key words:* coal smoke, indoor air pollution, passive cigarette smoke, passive respiratory symptoms, particulate pollution. *Environ Health Perspect* 101: 314–316(1993)

There is growing evidence that indoor air pollution can adversely affect respiratory health (*1*). Previous research has indicated that passive cigarette smoke is associated with increased respiratory symptoms, increased lower respiratory infections, and reduced lung function growth in small children (*2–4*), although for adults such associations are not as well established (*5–7*). In many parts of the world, including China, another major source of indoor air pollution is the use of free-standing, unvented coal stoves for home heating (*8*). Recent research in Beijing, China, indicated that reduced pulmonary function in adults is associated with indoor air pollution from coal heating (*9*). In the present study, we used data from a sample of never-smoking women in China to evaluate the combined effects of in-home air pollution from passive cigarette smoke and coal heating on reported prevalence of respiratory symptoms.

In 1992, a survey of 1035 married women who worked in three textile mills was conducted in the northern part of Anhui Province, China. In this part of China, many homes are heated by free-standing, unvented coal stoves. A Chinese translation of a standardized questionnaire (*10,11*) was used to obtain information on cigarette smoking, home heating, demographic characteristics, work-related activities, and various health endpoints including respiratory symptoms and reproductive history. Respiratory symptom questions were based on the 1978 American Thoracic Society respiratory questionnaire (ATS-DLD 1978) (*10*). The questionnaire was translated from English into Chinese, then back to English by a different translator to check for accuracy. It was reevaluated for clarity and corrected where necessary. Each questionnaire was administered by a trained nurse. Each woman was also asked to take a questionnaire home for her husband to complete and to return the completed questionnaire to the mill.

To assure a relatively young, nonsmoking, educated cohort, we used a subset of 973 of these women for this analysis. This subset included only women who 1) were 20–40 years of age, 2) had never smoked, and 3) had at least a middle or high school education. Thirty-five percent of the women lived in homes that were heated with coal stoves. All of the women worked in one of three textile mills in Anhui, China. Two of these mills, Huaibei First Textile Mill and Huaibei Second Textile Mill, were built in 1978; the third mill, Suzhou Textile Mill, was built in 1984. All three mills produced similar products and had comparable facilities, equipment, and manufacturing processes.

Five respiratory symptoms were defined based on yes/no responses to the symptoms questions in the questionnaire. "Chest illness" was defined as chest illness with increased cough or phlegm during the last 3 years; "cough" was defined as usually coughing in the morning or usually coughing during the day or night; "phlegm" was defined as usually bringing up any phlegm from the chest first thing in the morning or during day or night; "shortness of breath" (SOB) was defined as shortness of breath when walking with a person the same age at their own pace on level ground; and "wheeze" was defined as wheezing or whistling from the chest.

We calculated prevalence rates for each of the symptoms across strata and performed chi-square tests of homogeneity across the strata (*12*). Differences in prevalence of symptoms across homes with different number of smokers and with and without coal heating were observed (Table 1). The prevalence of chest illness, cough, phlegm, and SOB were generally higher for women living in homes with both coal heating and smokers. Effects of passive smoking were more pronounced in homes with coal heating than in homes without coal heating. The prevalence of chest illness, cough, phlegm, and SOB were approximately 2.4, 2.1, 2.8, and 2.2 times higher, respectively, for women in homes with both coal heating and more than one smoker than for women in homes without coal heating and with no smokers. Although the prevalence of wheeze was not positively associated with passive cigarette smoke, it was positively associated with coal heating.

Multiple logistic regression analysis (*13,14*) of these data also produced similar results (Table 2). We calculated adjusted odds ratios based on logistic regression models that used dummy variables to represent strata across homes with coal heat-

ing and passive smoking controlling for age, job title (manufacturing versus administrative/quality control), and mill. These models allowed for estimation of separate odds ratios for each stratum and allowed for unconstrained interaction between coal heating and passive smoke. The prevalence of chest illness, cough, phlegm, and SOB was significantly associated with women living in homes with smokers and coal heating. The prevalence of symptoms were positively associated with age and negatively associated with having administrative duties at the mill. Controlling for age, administrative duties, and the mill of employment did not diminish the prevalence of elevated symptoms for women who lived in homes with coal heat and smokers.

Socioeconomic differences between households may partially confound the association between respiratory symptoms and indoor air pollution. For example, where there are more smokers, there is likely to be more crowding in the home. The increase in respiratory symptoms may be associated with increased crowding and transmission of infectious respiratory disease rather than toxic effects of indoor air pollution. For a subset of participants in this study (909), enough information was available to calculate the square meters per person residing in the woman's home. Using these 909 observations, we conducted logistic regression analysis controlling

for the square meters per household member and combined income of each woman and her husband, in addition to age, job title, mill of employment. The estimated odds ratios were nearly equal to and usually slightly larger than those reported in Table 2, suggesting that the association between indoor air pollution and respiratory symptoms was not due to inadequate control of income or crowding.

The associations between respiratory symptoms and indoor air pollution from coal heating and passive cigarette smoke observed in this study are largely consistent with other studies. Associations between passive cigarette smoke and increased respiratory symptoms have been observed in children (2–4). For adults, the association between respiratory symptoms and passive cigarette smoke is not as well established (2–8). Similarly, in this study, when evaluated separately from coal heating, the association between passive cigarette smoking and respiratory symptoms was relatively weak. However, the combined effect of both passive cigarette smoke and coal heating was pronounced and statistically significant.

Associations between respiratory health and air pollution from coal combustion have been observed elsewhere. In a cross-sectional study of three areas of Beijing, China, heating with coal was associated with reduced lung function in nonsmoking adults (9). Furthermore, numerous studies have observed health effects of outdoor particulate pollution in areas where much of the pollution came from coal combustion sources (9,15–21).

In this study, the likelihood that observed associations between respiratory symptoms and passive cigarette smoke and coal heating were due to unknown or uncontrolled confounding factors is reduced because a relatively homogeneous cohort of women were studied. None of the women had ever smoked; all lived in the same area of China; all were 20–40 years of age; all had a middle or high school education; all were married; and all worked at one of three similar textile mills. Significant differences in prevalence of respiratory symptoms were observed between women who worked in administrative areas at the textile mill versus those who worked in manufacturing, suggesting differences in occupational exposures. Nevertheless, the association with in-home passive cigarette smoke and coal heating did not diminish after controlling for age, mill, and type of duties at the mill (administrative or manufacturing).

A major implication of this study is that health effects of passive cigarette smoke need to be evaluated within the context of combined exposures to multiple

Table 1. Respiratory symptom prevalence rates (expressed as percentages) across homes with and without coal heating and homes with no smokers, one smoker, and more than one smoker

| | | No coal heat | | | Coal heat | | | |
	Total	No smokers	1 Smoker	≥2 Smokers	No smokers	1 Smoker	≥2 Smokers	p^a
Number	973	182	409	42	101	203	36	—
Chest	7.2	7.1	7.1	0.0	2.0	9.9	16.7	0.013
Cough	12.7	12.1	12.5	16.7	9.9	12.3	25.0	0.277
Phlegm	18.0	12.1	16.6	21.4	18.8	22.2	33.3	0.020
SOB	9.2	7.7	8.8	7.1	5.0	12.8	16.7	0.131
Wheeze	9.9	8.8	8.6	7.1	15.8	11.3	8.3	0.305

SOB, shortness of breath.
^{a}The p-values are based on Pearson chi-square tests of homogeneity.

Table 2. Estimated odds ratios of respiratory symptoms with respect to passive smoking and coal heating adjusted for age, job title, and mill of employment by logistic regression

| | No coal heat | | | Coal heat | | |
	No smokers	1 Smoker	≥2 Smokers	No smokers	1 Smoker	≥2 Smokers
Chest	1.00	0.98 (0.50–1.94)^a	—	0.30 (0.07–1.39)	1.57 (0.74–3.31)	3.79** (1.28–11.2)
Cough	1.00	1.02 (0.60–1.75)	1.87 (0.71–4.88)	0.80 (0.35–1.81)	1.03 (0.97–1.10)	3.07** (1.23–7.65)
Phlegm	1.00	1.43 (0.85–2.40)	2.07 (0.85–5.01)	1.51 (0.76–3.00)	1.89** (1.07–3.35)	3.64*** (1.56–8.52)
SOB	1.00	1.17 (0.61–2.25)	1.46 (0.39–5.52)	0.74 (0.25–2.16)	1.88* (0.93–3.81)	3.55** (1.20–10.5)
Wheeze	1.00	0.93 (0.50–1.75)	1.00 (0.27–3.71)	1.83 (0.84–3.97)	1.20 (0.60–2.41)	1.07 (0.29–4.00)

SOB, shortness of breath.
^{a}95% confidence intervals of adjusted odds ratios.
*$p < 0.10$; **$p < 0.05$; ***$p < 0.01$ (p-values refer to comparisons to women without coal heat or smokers in home).

sources of indoor air pollution. Effects of passive cigarette smoke and effects of coal heating were larger when the other indoor pollution source was present. In homes with no other major indoor air pollution source, health effects of passive cigarette smoke on adults may be relatively small. However, in many parts of the world where most homes are heated by unvented combustion, combined respiratory health effects may be substantial.

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